

PATENT SPECIFICATION



DRAWINGS ATTACHED

879621

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Date of filing Complete Specification: July 1, 1960.

Application Date: July 7, 1959. No. 23273/59.

Complete Specification Published: Oct. 11, 1961.

Index at Acceptance:- Class 110(3), B2B2, G11.

International Classification:- F02c.

COMPLETE SPECIFICATION

Improvements in or relating to gas turbine engines

We, ROLLS-ROYCE LIMITED, a British Company of Nightingale Road, Derby, do hereby declare the invention, for which we pray that a patent may be granted to 5 us, and the method by which it is to be performed, to be particularly described in and by the following statement:-

This invention concerns gas turbine engines and has for its object the provision of means to prevent the formation 10 of ice on the leading edges of the air intakes of the engines.

According to the present invention 15 there is provided a gas turbine engine comprising ducting means arranged to be supplied with compressed air which has been compressed by the compressor means of the engine and heated thereby, said ducting means being adapted firstly to supply said heated air to the interior 20 of, compressor blading of the engine and/or of a strut extending across the air intake of the engine, so that the heated air passes through said blading and/or 25 strut radially inwardly and then radially outwardly by way of adjacent passageways so as to heat the blading and/or strut, and thereafter to supply said heated air 30 which has passed through said blading and/or strut to, so as to effect heating of, the leading edge of the air intake.

The said compressor blading may 35 comprise the first stage stator blades of the compressor means while the said compressor means may comprise a low pressure and a high pressure compressor, the ducting means being arranged to be supplied with air from the downstream end of the high pressure compressor.

40 Preferably the arrangement is such that air from the downstream end of the high pressure compressor is conveyed to an annular manifold surrounding the upstream end of the low pressure, the air 45 in the manifold being caused to flow

[Price]

down the centre of tubes, each of which is provided in an air intake strut, and down the interior of the leading edge of each first stage stator blade, a portion of the air after flowing down the tubes being caused to flow up the interior of the leading and trailing edges of the intake struts and being exhausted into a first annular chamber, the remainder of the air flowing down the tubes being used to heat a bullet-shaped baffle in the air intake of the engine, the air after flowing down the leading edge of the stator blades being caused to flow up the interior of the trailing edges of these blades and being exhausted into a second annular chamber, the first and second annular chambers being connected to a conduit communicating with an annular manifold provided within the interior of the leading edge of the air intake, said manifold having apertures for directing the hot air delivered to the manifold from said first and second chambers onto the inner surface of the leading edge of the air intake to heat it.

Preferably means are provided for returning the heated air, which has been used to heat the leading edge of the air intake, into the intake duct of the engines.

The invention is illustrated, merely by way of example, in the drawings accompanying the provisional specification, 80 in which:-

Figure 1 is an elevation, partly in section, of a gas turbine, jet propulsion engine of the by-pass type embodying the present invention, 85

Figure 2 is a sectional elevation of part of the engine shown in Figure 1, and

Figures 3, 4, 5, 6 are sections taken respectively on the lines 3-3, 4-4, 5-5 and 6-6 of Figure 2. 90

In Figure 1 there is shown a gas turbine, jet-propulsion engine of the bypass type for use in propelling an aircraft. The engine comprises in flow 5 series an air intake duct 10, a low pressure compressor 11, a high pressure 12, combustion equipment 13, and high and low pressure turbines 14, 15 respectively. The exhaust gases from the 10 turbines 14, 15 are directed through a jet pipe 16.

The high pressure turbine 14 drives the high pressure compressor 12 through a shaft 17, whilst the low pressure 15 turbine 15 drives the low pressure compressor 11 through a shaft 18 which is concentric with and mounted within the shaft 17.

The upstream, or inlet, end of an annular by-pass duct 19, one of whose walls is provided by an engine casing 20, communicates with a space between the low and high pressure compressors 11, 12. The by-pass duct 19 thus obtains a supply of compressed air from the low pressure compressor 11. The compressed air flowing through the by-pass duct 19 bypasses the high pressure compressor 12, the combustion equipment 13, and the 25 high and low pressure turbines 14, 15. The by-pass air is discharged through apertures 21 into the jet pipe 16 so as to mix therein with the turbine exhaust gases.

The intake duct 10 is provided within an air intake casing 22, the upstream end of the shaft 18 being journalled within bearings 23 which are supported from the casing 22 by hollow, vane-shaped struts 24. The struts 24 (see Figure 6) are arranged tangentially of the shaft 18 so as to minimise the risks of their buckling when heated.

An annular manifold 25 is mounted 45 about the portion of the casing 22 which surrounds the air intake struts 24 and the first stage stator blades 26 of the low pressure compressor 11. The manifold 25 is divided into an upstream 50 chamber 27, a central chamber 28, and a downstream chamber 29. The chambers 27, 28 are separated from each other by walls 30, 31 while the chambers 28, 29 are separated from each other by a wall 32.

A duct 33, incorporating a shut-off cock 34, communicates with the downstream, or outlet, end of the high pressure compressor 12 and also with the central 55 chamber 28. The cock 34 may be manually controlled or may be automatically controlled, e.g. by temperature responsive means. When the cock 34 is open, air which has been heated by passing through the low and high pressure compressors 11, 12 will be supplied to the central 60

chamber 28.

Extending centrally of each of the air intake struts 24 is a tube 35 whose radially inner end is spaced from the inner end of the respective strut 24. 70 The radially outer end of each tube 35, communicates with the interior of a cap member 36 which is disposed partly within the manifold 25 and partly within the respective strut 24. Each cap member 75 36 has an aperture 37 therethrough which communicates with the central chamber 28 by means of a tube 38 mounted in the walls 30, 31.

Some of the heated air from the central chamber 28 will thus flow through the tube 38 and then flow radially inwardly through each tube 35 and will then divide so as to flow radially outwardly over the leading and trailing edges of 85 the respective strut 24 and so into the upstream chamber 27.

The inner ends of the struts 24 are contiguous and communicate with each other by holes 39 which ensure that the 90 pressures within the various struts are the same.

Immediately upstream of the struts 24 is a bullet-shaped, double walled, air intake baffle 40 which serves to form 95 the air flowing through the air intake duct 10 into an annular stream suitable for passage through the compressor 11. Mounted between the inner and outer walls 41, 42 of the baffle 40 are a plurality 100 of tubes 43 each of which communicates with the interior of a respective strut 24.

Heated air from the inner end of each strut 24 may thus flow through a tube 105 43 and over the walls 41, 42. This air will then flow out into the air intake duct 10 through apertures 44, 45 formed in wall members of the baffle 40.

Each of the stator blades 26 is 110 hollow and has mounted within it a tube 46 whose radially inner end is spaced from the radially inner end of the respective blade 26. Heated air from the chamber 28 may flow radially inwardly over the leading edge of the blade 26. The tube 46 serves as a baffle and the heated air passes radially outwardly up the trailing edge of the blade 26 and so into the downstream 120 chamber 29 via holes 47 in the wall 32.

A duct 48 communicates with the chambers 27, 29 and with a manifold 49 disposed adjacent the leading edge 50 of the air intake casing 22. The manifold 49 has ports 51 communicating with a channel 52 formed between the upstream portion of the casing 22 and a baffle 53. Heated air, after it has been used to heat the struts 24 and 125 130

blades 26, is thus passed to the channel 53 whereby to heat the leading edge 50, the air being subsequently returned to the air intake duct 10 via holes 54 in 5 the casing 22.

The construction shown in the drawings thus provides an economical way of heating the blades 26, struts 24, baffle 40 and leading edge 50 of the air intake so 10 as to prevent icing up of these parts.

Alternatively the holes 54 may be omitted and the air ejected overboard after heating the leading edge 50.

WHAT WE CLAIM IS:-

- 15 1. A gas turbine engine comprising ducting means arranged to be supplied with compressed air which has been compressed by the compressor means of the engine and heated thereby, said ducting means being adapted firstly to supply said heated air to the interior of, compressor blading of the engine and/or of a strut extending across the air intake of the engine, so that the heated 20 air passes through said blading and/or strut radially inwardly and then radially outwardly by way of adjacent passageways so as to heat the blading and/or strut, and thereafter to supply said heated air 25 which has passed through said blading and/or strut to, so as to effect heating of, the leading edge of the air intake.
- 20 2. A gas turbine engine as claimed in claim 1 in which the said compressor 30 blading comprises the first stage stator blades of the compressor means.
- 25 3. A gas turbine engine as claimed in claim 2 comprising means for causing the heated air to flow over the leading edges 35 of the first stage stator blades prior to flowing over the trailing edges thereof.
- 30 4. A gas turbine engine as claimed in any preceding claim in which the compressor means comprises a low pressure 40 and a high pressure compressor, the ducting means being arranged to be supplied with air from the downstream end of the high pressure compressor.
- 45 5. A gas turbine engine as claimed in any preceding claim comprising means for returning the heated air, which has been used to heat the leading edge of the air intake, into the intake duct of the engines.

6. A gas turbine engine as claimed in claim 4 in which the arrangement is such that air from the downstream end of the high pressure compressor is conveyed to an annular manifold surrounding the upstream end of the low pressure compressor, the air in the manifold being caused to flow down the centre of tubes, each of which is provided in an air intake strut, and down the interior of the leading edge of each first stage stator blade, a portion of the air after flowing down the tubes being caused to flow up the interior of the leading and trailing edges of the intake struts and being exhausted into a first annular chamber, the remainder of the air flowing down the tubes being used to heat a bullet-shaped baffle in the air intake of the engine, the air after flowing down the leading edge of the stator blades being caused to flow up the interior of the trailing edges of these blades and being exhausted into a second annular chamber, the first and second annular chambers being connected to a conduit communicating with an annular manifold provided within the interior of the leading edge of the air intake, said manifold having apertures for directing the hot air delivered to the manifold from said first and second chambers onto the inner surface of the leading edge of the air intake to heat it.

7. A gas turbine engine substantially as described with reference to and as shown in the drawings accompanying the provisional specification.

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PROVISIONAL SPECIFICATION

No. 23273 A.D. 1959

Improvements in or relating to gas turbine engines

We, ROLLS-ROYCE LIMITED, a British 95 Company, of Nightingale Road, Derby, do hereby declare this invention to be

described in the following statement:-
This invention concerns gas turbine engines and has for its object the

provision of means to prevent the formation of ice on the leading edges of the air intakes of the engines.

According to the present invention 5 there is provided a gas turbine engine comprising ducting means arranged to be supplied with air which has been compressed by the compressor means of the engine and heated thereby, said ducting 10 means being adapted firstly to supply said heated air to, so as to heat the interior of compressor blading and/or of a strut extending across the air intake of the engine, and thereafter to supply 15 said heated air to, so as to effect heating of, the leading edge of the air intake.

The said compressor blading may comprise the first stage stator blades of 20 the compressor means while the said compressor means may comprise a low pressure and a high pressure compressor, the ducting means being arranged to be supplied with air from the downstream 25 end of the high pressure compressor.

Preferably air from the downstream end of the high pressure compressor is conveyed to an annular manifold surrounding the upstream end of the low pressure compressor, the air in the manifold being caused to flow down the centre of a tube provided in each air intake strut and down the interior of the leading edge of each first stage stator blade, 30 a portion of the air after flowing down the tubes being caused to flow up the interior of the leading and trailing edges of the intake struts and being exhausted into a first annular chamber, 35 the remainder of the air flowing down the tubes being used to heat a bullet-shaped baffle in the air intake of the engine, the air after flowing down the leading edge of the stator blades being 40 caused to flow up the interior of the trailing edges of these blades and being exhausted into a second annular chamber, the first and second annular chambers being connected to a conduit communicating 45 with an annular manifold provided within the interior of the leading edge of the air intake, said manifold having apertures for directing the hot air delivered to the manifold from said first 50 and second chambers onto the inner surface of the leading edge of the air intake to heat it.

Preferably means are provided for returning the heated air, which has been 60 used to heat the leading edge of the air intake, into the intake duct of the engines.

The invention is illustrated, merely by way of example, in the accompanying 65 drawings in which:-

Figure 1 is an elevation, partly in section, of a gas turbine, jet reaction engine and of the by-pass type embodying the present invention,

Figure 2 is a sectional elevation of 70 part of the engine shown in Figure 1, and

Figures 3, 4, 5, 6 are sections taken respectively on the lines 3-3, 4-4, 5-5, and 6-6 of Figure 2.

In Figure 1 there is shown a gas turbine, jet-reaction engine of the by-pass type for use in propelling an aircraft. The engine comprises in flow series an air intake duct 10, a low pressure 11, a high pressure compressor 12, combustion equipment 13 and high and low pressure turbines 14, 15 respectively. The exhaust gases from the turbines 14, 15 are directed through a jet pipe 16.

The high pressure turbine 14 drives 85 the high pressure compressor 12 through a shaft 17, whilst the low pressure turbine 15 drives the low pressure compressor 11 through a shaft 18 which is concentric with and mounted within the 90 shaft 17.

The upstream, or inlet, end of an annular by-pass duct 19, one of whose walls is provided by an engine casing 20, communicates with a space between the low 95 and high pressure compressors 11, 12. The by-pass duct 19 thus obtains a supply of compressed air from the low pressure compressor 11. The compressed air flowing through the by-pass duct 19 by-passes the high 100 pressure compressor 12, the combustion equipment 13, and the high and low pressure turbines 14, 15. The by-pass air is discharged through apertures 21 into the jet pipe 16 so as to mix therein 105 with the turbine exhaust gases.

The intake duct 10 is provided within an air intake casing 22, the upstream end of the shaft 18 being journaled within bearings 23 which are supported 110 from the casing 22 by hollow, vane-shaped struts 24. The struts 24 (see Figure 8) are arranged tangentially of the shaft 18 so as to minimise the risks of their buckling when heated. 115

An annular manifold 25 is mounted about the portion of the casing 22 which surrounds the air intake struts 24 and the first stage stator blades 26 of the low pressure compressor 11. The manifold 120 25 is divided into an upstream chamber 27, a central chamber 28, and a downstream chamber 29. The chambers 27, 28 are separated from each other by walls 30, 31 while the chambers 28, 29 are separated from each other by a wall 32.

A duct 33, incorporating a shut-off cock 34, communicates with the downstream, or outlet, end of the high 125 130

pressure compressor 12 and also with the central chamber 28. The cock 34 may be manually controlled or may be automatically controlled - e.g. by temperature responsive means. When the cock 34 is open, air which has been heated by passing through the low and high pressure compressors 11, 12 will be supplied to the central chamber 28.

10 Extending centrally of each of the air intake struts 24 is a tube 35 whose radially inner end is spaced from the inner end of the respective strut 24. The radially outer end of each tube 35 communicates with the interior of a cap member 36 which is disposed partly within the manifold 25 and partly within the respective strut 24. Each cap member 36 has an aperture 37 therethrough which 15 communicates with the central chamber 28 by means of a tube 38 mounted in the walls 30, 31.

20 Some of the heated air from the central chamber 28 will thus flow through the tube 38 and then flow radially inwardly through each tube 35 and will then divide so as to flow radially outwardly over the leading and trailing edges of the respective strut 24 and so 25 into the upstream chamber 27.

25 The inner ends of the struts 24 are contiguous and communicate with each other by holes 39 which ensure that the pressures within the various struts are the same.

30 Immediately upstream of the struts 24 is a bullet-shaped, double walled, air intake baffle 40 which serves to form the air flowing through the air intake duct 10 into an annular stream suitable 35 for passage through the compressor 11. Mounted between the inner and outer walls 41, 42 of the baffle 40 are a plurality of tubes 43 each of which communicates 40 with the interior of a respective strut 24.

Heated air from the inner end of each strut 24 may thus flow through a tube 43 and over the walls 41, 42. This air will then flow out into the air intake duct 10 through apertures 44, 45 formed in wall members of the baffle 40.

50 Each of the stator blades 26 is hollow and has mounted within it a tube 46 whose radially inner end is spaced from the radially inner end of the respective blade 26. Heated air from the chamber 28 may flow radially inwardly over the leading edge of the blade 26. The tube 46 serves as a baffle and the heated air passes radially outwardly up the trailing edge of the blade 26 and so into the downstream chamber 29 via holes 47 in the wall 32.

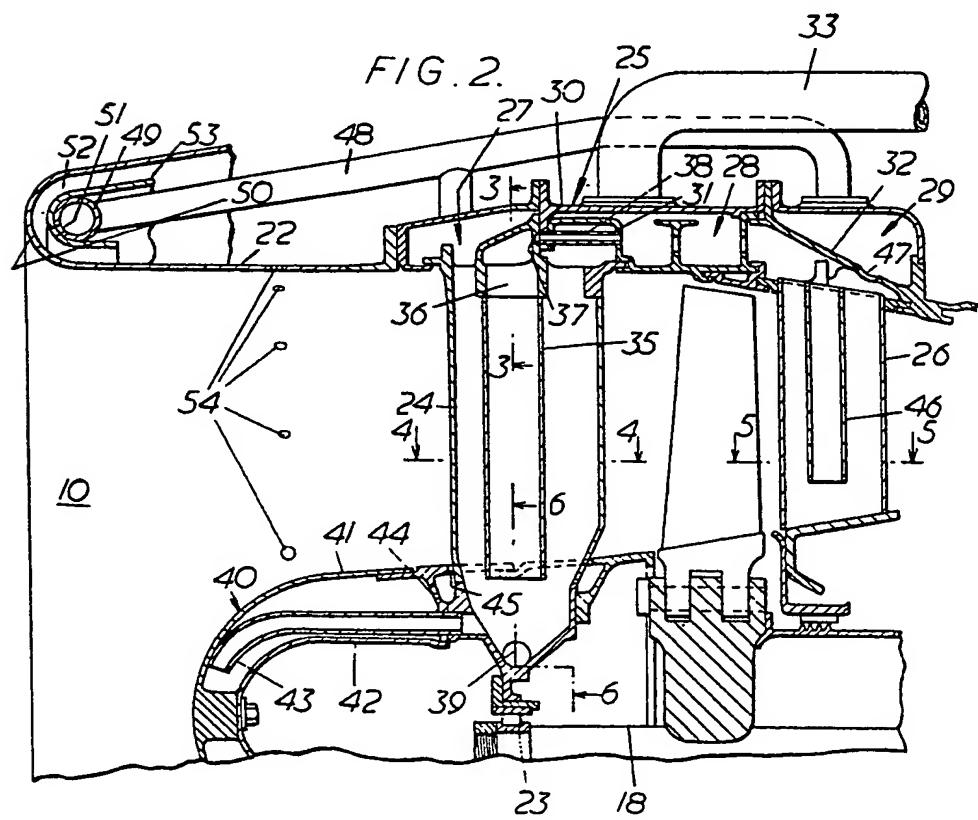
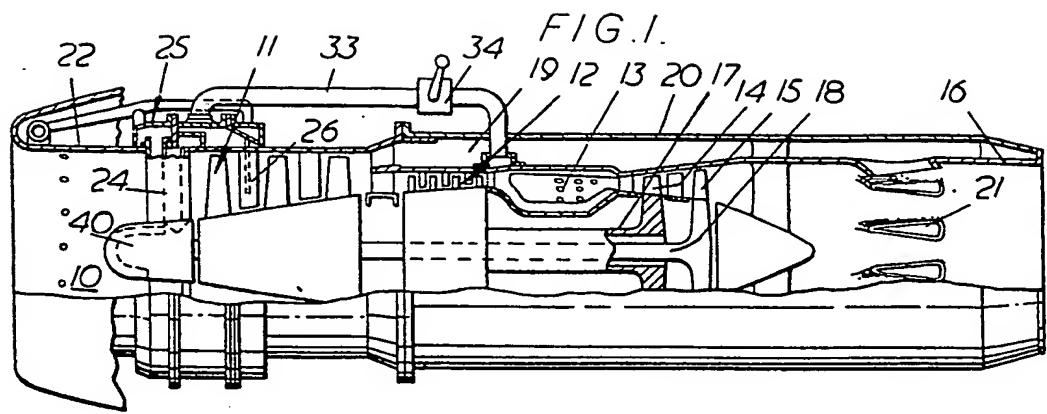
55 A duct 48 communicates with the chambers 27, 29 and with a manifold 49 disposed adjacent the leading edge 50 of the air intake casing 22. The manifold 49 has ports 51 communicating with a channel 52 formed between the upstream portion of the casing 22 and a baffle 53. Heated air, after it has been used to 60 heat the struts 24 and blades 26, is thus passed to the channel 53 whereby to heat the leading edge 50, the air being subsequently returned to the air intake 65 duct 10 via holes 54 in the casing 22.

70 The construction shown in the drawings thus provides an economical way of heating the blades 26, struts 24, baffle 75 40 and leading edge 50 of the air intake so as to prevent icing up of these parts.

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PROVISIONAL SPECIFICATION

2-SHEETS

*This drawing is a reproduction of
the Original on a reduced scale.*

SHEETS 1 & 2

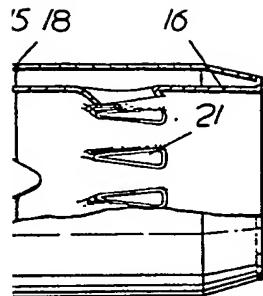


FIG. 3.

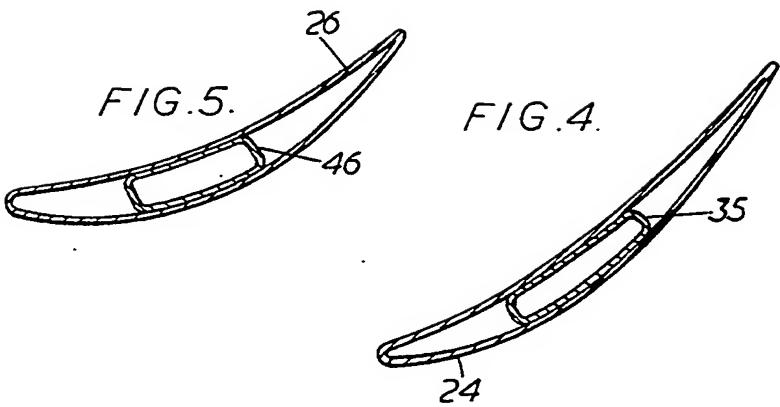
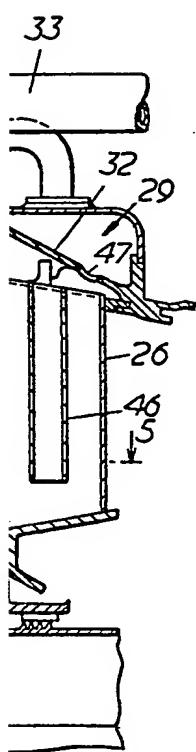
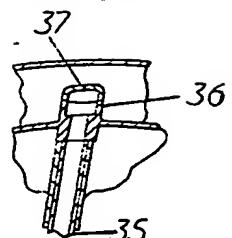
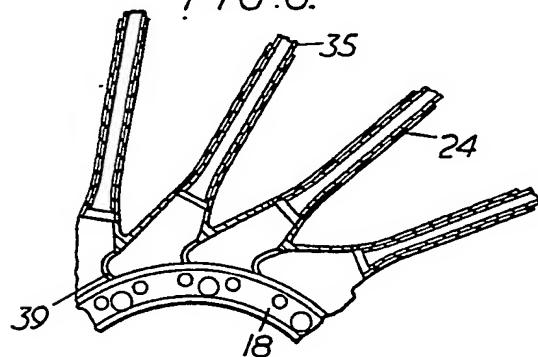


FIG. 6.



878,621 PROVISIONAL SPECIFICATION
 2 SHEETS This drawing is a reproduction of
 the Original on a reduced scale.
 SHEETS 1 & 2

